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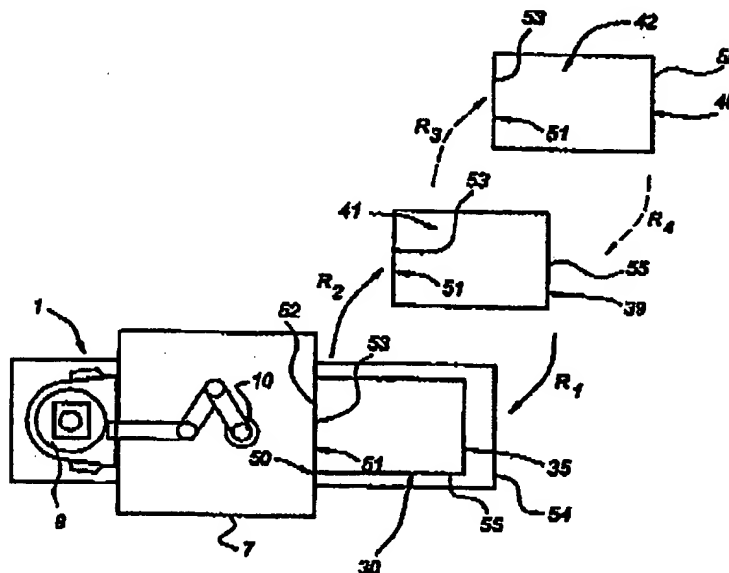
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(54) Title: MODULAR SUBSTRATE MEASUREMENT SYSTEM



(57) Abstract: Substrate measurement system including a measurement chamber (30), and a substrate handling chamber (7) possessing substrate transfer means (10) and a substrate container interface (1) arranged to receive a substrate container (8), the handling chamber (7) containing a first interface (50) to connect the measurement chamber (30), the measurement chamber (30) containing a second interface (51) to connect to the handling chamber (7), and the transfer means (10) being arranged to transfer substrates between the container (8) and the measurement chamber (30) through the handling chamber (7), in which system a second measurement chamber (39) is provided, having the same second interface (51) as the first measurement chamber (30) to replace the latter chamber (30).

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**Modular substrate measurement system****Field of the invention**

The invention relates to an assembly of a substrate measurement system as defined in the preamble of claim 1.

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**Prior Art**

Such a cluster tool is known from WO 99/49500, in which, in order to reduce cycle time overhead, an inspection tool (e.g. a optical microscope) and one or more review tools (e.g. a scanning electron microscope and/or an atomic force microscope) are linked by an automation platform that handles wafer transport between the tools and a substrate container interface. Although the cluster tool is designed to be optimised with respect to the throughput from one tool (e.g. inspection) to another (e.g. one of the provided review tools), the flexibility of the cluster in terms of maintenance and repair of one of the tools is low: in such a case the complete cluster will be out of order. Also, flexibility in terms of reconfiguring a cluster tool on-site for a different type of wafer analysis, by just a simple replacement of the measurement tools is low.

**Summary of the invention**

It is the objective of the present invention to provide a solution for these problems by a more flexible arrangement of the measurement tools and the substrate transfer means involved.

The present invention relates to an assembly of a substrate measurement system as defined in the preamble of claim 1, characterised in that a second measurement chamber is provided, which fits within the same dimensions as said first measurement chamber and is provided with the same identical interface as said first measurement chamber to replace said first measurement chamber.

The present invention provides a substrate measurement system comprising a central substrate handling chamber which is provided with substrate transfer means, at least one substrate container interface with a standardised interface and arranged to receive a matching substrate container, and a mechanical interface to receive a measurement chamber comprising a measurement instrument. The measurement chamber has a

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standardised size and is provided with standardised mechanical interface, in order to connect to the corresponding interface of the substrate handling chamber. Because of the standardisation of the measurement chamber, the modular substrate measurement system can easily be configured with different types of measurement instruments for a certain application by a simple replacement of one measurement chamber by another chamber.

According to a preferred embodiment of the present invention, the central substrate handling chamber comprises two or more measurement chambers of standardised size and provided with a standardised mechanical interface. In this embodiment, the substrate transfer means are shared by the two or more measurement instruments inside their respective measurement chambers and the substrate container interface, resulting in savings in cost and floor space. Moreover, two or more measurements on a single wafer can be executed sequentially without time delay. In this embodiment, more than one substrate container interface can be connected to the substrate handling chamber.

The measurement chambers can be distributed in a substantially horizontal plane but they can also be stacked in a substantially vertical direction.

According to a further embodiment of the present invention, the substrate measurement system comprises a substrate container stocker system arranged to store a plurality of substrate containers, each containing a batch of wafers awaiting measurements, and substrate container transfer means. The substrate container transfer means transfer substrate containers between the stocker system and the substrate container interface of the substrate handling chamber. In this manner, a further increase in efficiency is possible by providing a wafer storage buffer in the stocker system. Due to the physical separation of the functionality of process tools and measurement tools, the delay times in both the process tools and the measurement tools may be reduced since their respective cycle times are no longer dependent on each other.

According to a further embodiment of the present invention, the substrate container interfaces and the mechanical interface of the substrate handling chamber arranged to connect to a measurement chamber are standardised, so that at choice a station can receive either a substrate container or a measurement chamber. In this way, the flexibility of a modular substrate measurement system is increased even further. The system can be adapted to specific needs within a short time. Also, replacement and

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repair of a measurement chamber containing a defective measurement instrument may be strongly simplified due to the modularity of the system.

#### **Brief description of drawings**

Below, the invention will be explained with reference to the drawings, which are intended for illustration purposes only and not to limit the scope of protection as defined in the accompanying claims.

Figure 1 is a schematic top view diagram showing a substrate measurement system according to a first embodiment;

Figure 2 is a schematic top view diagram showing a substrate measurement system according to a second embodiment;

Figure 3 is a schematic top view diagram showing a substrate measurement system according to a third embodiment;

Figure 4a is an exploded perspective view of a substrate measurement system according to the fourth embodiment;

Figure 4b is a schematic top view diagram showing a substrate measurement system according to a fourth embodiment;

Figure 5a is an exploded perspective view of a substrate measurement system according to the fifth embodiment;

Figure 5b is a schematic top view diagram showing a substrate measurement system according to a fifth embodiment.

#### **Description of preferred embodiments**

Figure 1 shows a substrate measurement system comprising a centrally mounted substrate handling chamber 7, provided with wafer transfer means 10. The substrate handling chamber is provided with a substrate container interface 1 and a mechanical interface 50 on which a measurement chamber 30 is connected. Substrate container interface 1 is connected to substrate handling chamber 7. On substrate container interface 1 a substrate container 8 is mounted. Substrate container interface 1 provides a standardised mechanical interface on which the substrate container 8 is connected by means of a corresponding interface.

In the measurement chamber 30 a measurement instrument 35 is provided for a certain application, e.g. measurement of the thickness of a film on a wafer. Both substrate handling chamber 7 and measurement chamber 30 comprise standardised

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mechanical interfaces: the mechanical interface 50 provided on the substrate handling chamber 7 and the matching interface 51 on the measurement chamber 30 are standardised.

5       The mechanical interface 50 and the matching interface 51 both provide matching coupling parts 52, and 53, respectively, for coupling the measurement chamber 30 to the substrate handling chamber 7. The coupling provides a gastight sealable coupling between the measurement chamber 30 and the substrate handling chamber 7. In this manner, the measurement chamber 30 can be used under controlled vacuum pressure  
10       conditions. Also, the mechanical interface 50 provides a mechanical support area 54 for supporting the measurement chamber 30 on a matching support area 55 of the mechanical interface 51. The support areas 54, 55 may be arranged as a substantially horizontal area, a substantially vertical area, or a combination of both. The fit of such a mechanical support area 54 and a matching support area 55 may provided in any  
15       conceivable way as known in the art.

Thus, by the arrangement of the mechanical interface 50 and the matching interface 51 as described above, the measurement chamber 30 can easily be replaced by another measurement chamber such as 39 or 40, each also provided with the  
20       standardised mechanical interface 51 and its respective measurement instrument 41 or 42, specific to their respective desired application. The replacement of measurement chambers is schematically indicated in Figure 1 by arrows R1, R2, R3 and R4.

To permit easy replacement of a measurement chamber 30, 39, 40, and to have  
25       truly portable measurement chambers, a measurement chamber with its contents, preferably, does not weigh more than about 15-30 kilograms and, preferably, has a maximum size of about 50 centimetres in length, width and height. In this way, a measurement chamber can be replaced quickly within a few minutes, and a very flexible measurement procedure is obtained.

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In a particular embodiment, the measurement interfaces 50 and 51 can be designed and dimensioned as Front-Opening Unified Pod (FOUP) interfaces according to SEMI standard E 47.1. In this design a pod is supported on a platform by three

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support pins, which fit in three recessions in the bottom of the pod, everything dimensioned in prescribed dimensions.

Figure 2 shows a second embodiment of the present invention of a substrate measurement system wherein a plurality of stations is distributed in a substantially horizontal plane around a centrally mounted substrate handling chamber 7, provided with wafer transfer means 10. The substrate handling chamber has the shape of a regular hexagon, but other shapes, including shapes with less or more sides, and/or irregular shapes are also possible. Two substrate container interfaces 1 and 2 are shown with substrate container 8 and 9 installed on substrate container interface 1 and 2, respectively. Four measurement chambers 30, 31, 32, 33 are shown, each connected to substrate handling chamber 7. The measurement chambers 30, 31, 32, 33 comprise a respective measurement instrument 35, 36, 37 and 38, specific to the application of each measurement chamber. The measurement chambers 30, 31, 32, 33 have standardised dimensions and standardised mechanical interfaces 51 matching the standardised interfaces 50 of the substrate handling chamber 7 in such a manner that any of the measurement chambers 30, 31, 32 or 33, can be interchangeably mounted on any one position of the measurement chambers 30, 31, 32 or 33.

The substrate transfer means are capable of transferring a substrate from any of the substrate containers 8, 9, located on substrate container interfaces 1, 2, by means of their interfaces 80, 81, in any required sequence along any number of the measurement chambers 30, 31, 32, 33 and of returning the substrate in either, the same substrate container or the other substrate container, respectively.

During measurement of a substrate in any of the measurement instruments 35, 36, 37, 38, located in one of the measurement chambers 30, 31, 32, 33, the substrate can be supported by the substrate transfer means 10. But, most preferably, the substrate is supported on substrate support means (not shown) inside the measurement chamber 35, 36, 37, 38 and the substrate transfer means 10 are retracted from the measurement chamber 30, 31, 32, 33. In this way, during measurement of one substrate in one measurement instrument, the substrate transfer means 10 is available to transfer other substrates to and from one of the other measurement instruments.

The substrate handling chamber 7 can also be equipped with a station for substrate aligning or for substrate identification, as known in the art. Alternatively, one of the measurement chambers can be equipped with a station for substrate aligning and/or for

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substrate identification. When two or more substrate container interfaces 1, 2 are provided, one of the substrate containers could be used for substrates that are rejected on the basis of the results of the measurement(s) performed on them.

In the embodiment of Figure 2, each measurement chamber 30, 31, 32, 33 can easily be replaced by one of a plurality of other measurement chambers 39, 40, that are each provided with its respective measurement instrument 41 or 42, specific to the desired application.

Figure 3 shows a modular substrate measurement system according to a third embodiment wherein the substrate container interfaces 1, 2, 3 and the measurement chambers 30, 31, 32 are grouped in linear arrays around an elongated substrate handling chamber 7. Between substrate handling chamber and measurement chambers, mechanical interfaces 50 and 51 are provided as described in the previous embodiments. On the substrate container interfaces 1, 2, 3 substrate containers 8, 9, 11 are mounted. The substrate transfer means 10 comprise means for a linear translation in the substantially longitudinal direction of the substrate handling chamber 7, as indicated by the arrows T1 and T2.

In the embodiment of Figure 3, due to the standardised mechanical interfaces 50 and 51, each measurement chamber 30, 31, 32 can easily be replaced by one of a plurality of other measurement chambers 39, 40, that are each provided with its respective measurement instrument 41 or 42, specific to the desired application. Also, due to the standardised mechanical interfaces 50 and 51, the measurement chambers 30, 31, 32 can be mutually exchanged in any way selected.

Figure 4a and 4b show a substrate measurement system according to a fourth embodiment. As shown in Figure 4a in an exploded perspective view of this embodiment, two substrate container interfaces 1, 2 are provided, stacked on each other in a vertical direction. Substrate containers 8, 9 are mounted on their respective substrate container interfaces 1, 2. Measurement chambers 30, 31, 32, 33 provided with measurement instruments 35, 36, 37, 38 are linked to a central substrate handling chamber 7, by means of the standard mechanical interfaces 51 on the chambers 30, 31, 32 and one of the corresponding interfaces 50 of the chamber 7. The measurement chambers are distributed here both in a substantially horizontal and a substantially vertical direction. The measurement chamber 30 is next to the station 31 at a right



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angle. The chamber 31 is on top of the chamber 32, and the chamber 30 is on top of the chamber 33 (not visible).

In this embodiment, the substrate transfer means 10 of substrate handling chamber 7 is capable of transferring substrates to and from stations 1, 2, 30, 31, 32, 33 both in a substantially horizontal and a substantially vertical direction.

In Figure 4b a top view of this embodiment of the present invention is shown. The measurement chambers 30 and 31 are located at a 90° angle with respect to their front sides. It is to be understood that any other suitable angle between the measurement chambers can be used as well.

In the embodiment of Figure 4a and 4b, due to the standardised mechanical interfaces 50 and 51, each measurement chamber 30, 31, 32, 33 can easily replaced by one of a plurality of other measurement chambers 39, 40 (not shown), that are each provided with its respective measurement instrument 41 or 42, specific to the desired application. Also, due to the standardised mechanical interfaces 50 and 51, the measurement chambers 30, 31, 32, 33 can be mutually exchanged in any way selected.

Figure 5a and 5b show the substrate measurement system according to a fifth embodiment, wherein the substrate measurement system is provided with a substrate container stocker and substrate container transfer means to transfer substrate container between the substrate container stocker and the substrate container interfaces.

As shown in Figure 5a in an exploded perspective view of this embodiment, two substrate container interfaces 1, 2 are provided, stacked on each other in a vertical direction. Substrate containers 8, 9 are mounted on their respective substrate container interfaces 1, 2. Measurement chambers 30, 31, 32, 33 provided with measurement instruments 35, 36, 37, 38 are linked to a central substrate handling chamber 7, by means of the standard mechanical interfaces 51 on the stations 30, 31, 32 and one of the corresponding interfaces 50 of the chamber 7. The measurement chambers are distributed here both in a substantially horizontal and a substantially vertical direction. The measurement chamber 30 is next to the chamber 31 at a right angle. The chamber 31 is on top of the chamber 32, and the chamber 30 is on top of chamber 33 (not visible).

In this embodiment, the substrate transfer means 10 of substrate handling chamber 7 is capable of transferring substrates to and from stations 1, 2, 30, 31, 32 both in a substantially horizontal and a substantially vertical direction.

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- Substrate containers 8, 9 mounted on the substrate container interfaces 1, 2, are transferred to and from the substrate container stocker 19 by transfer means 17 and 21. In the substrate container stocker 19, substrate containers are stored in a carrousel 14 which comprises a plurality of storage shelves 16. Each shelf 16 can rotate around a central axis 20 in the carrousel and can contain a number of substrate containers. The substrate container stocking means 17 can transfer containers in both a substantially horizontal and substantially vertical direction to reach certain locations in the carrousel. Substrate containers can be entered in the system by means of the substrate container entrance stations 12, 13 which provide interfaces for mounting substrate containers which can be simplified as compared to the substrate container interfaces 1 and 2. The transfer means 17 and 21 transfer the substrate containers from the substrate container entrance stations 12 and 13 to the substrate container stocker 19. Also, the transfer means 17 and 21 can transfer a substrate container directly from a substrate container entrance station 12, 13 to a substrate container interface 1, 2 and vice versa.
- As is known in the art, it is possible to provide just one entrance station 12 or more than two entrance stations. An operator 18 can monitor and operate the system by means of a control unit comprising means for displaying and entering commands, e.g., a touch screen 15. The control unit may comprise other means (not shown) as required for its function, as is known in the art.
- Alternatively, the substrate container stocker may comprise a linear storeroom, in which containers are stored on rectangular shelves instead of inside the carrousel 14, and linear substrate container transfer means instead of the substrate container transfer means 17 and 21.
- In the embodiment of Figure 5a and 5b, due to the standardisation of the mechanical interfaces 50 and 51, each measurement chamber 30, 31, 32, 33 can easily be replaced by one of a plurality of other measurement chambers 39, 40 (not shown), that are each provided with its respective measurement instrument 41 or 42, specific to the desired application. Also, due to the standardised mechanical interfaces 50 and 51, the measurement chambers 30, 31, 32, 33 can be mutually exchanged in any way selected.
- The substrate handling chamber 7 can have a dust-free air atmosphere but also a controlled or protective atmosphere of an inert gas like nitrogen  $N_2$  or a noble gas like argon Ar may be provided. Alternatively, it is possible to have the substrate handling chamber 7 evacuated. In that case, the substrate container interfaces 1, 2, 3 provide a

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load-lock to transfer substrates from the substrate containers 8, 9, 11 to and from vacuum.

Similarly, the measurement instrument 35, 36, 37, 38 may require specific atmospheric conditions like a protective ambient (nitrogen or argon), or vacuum. In that case, the measurement chamber 30, 31, 32, 33 and/or the substrate handling chamber 7 provide means to supply, maintain and confine the ambient within the measurement chamber.

It will be understood that the measurement instrument 35, 36, 37, 38 as mounted on the measurement chamber 30, 31, 32, 33 comprises the essential parts to facilitate the measurement. However, other parts like e.g. a power supply, a vacuum pump, or a computer system linked to a measurement instrument, can be mounted at some distance of the measurement instrument 35, 36, 37, 38 and/or the measurement chamber 30, 31, 32, 33, as will be known to persons skilled in the art. These other parts may be placed remotely from the substrate measurement system, if required.

It will be understood that, in particular when the sensor of the measurement instrument is small, a measurement chamber can comprise more than one sensor.

It will also be clear that for the first three embodiments the stations can also be stacked in a substantially vertical direction.

Typically, one desires to perform measurements at a number of locations spread over the substrate surface area. This can be realised by translating the substrate in two horizontal and orthogonal directions. However, this requires a lot of space: about two times the dimension of the substrate in both directions. By keeping the dimensions of each measurement chamber small the modularity of the system can be exploited to the full extent by connecting a plurality of measurement chambers to the substrate handling chamber while keeping the overall dimensions of the system within acceptable limits.

To this end, the measurement chambers 30-33, 39, 40 are preferably provided with rotating means to rotate the substrate support means which support the substrate. In the measurement chamber 30-33, 39, 40 a sensor of a measurement instrument 35-38, 41, 42 is provided with sensor transfer means to translate the sensor relative to the substrate, in order to facilitate substrate mapping measurements.

The sensor transfer means may provide a linear displacement of the sensor, for example in a horizontal direction, perpendicular to the coupling part 53 of the interface 51, or diagonally across the measurement chamber 30-33, 39, 40. Also, for example, the sensor transfer means may provide a displacement of the sensor in a horizontal

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direction along a curved trace, when the sensor is attached to a sensor transfer means that can rotate around a mounting point.

Alternatively, the measurement sensor can be mounted at a fixed position within the measurement chamber 30-33, 39, 40. In that case, the substrate support means are provided with support transfer means to displace the substrate relative to the sensor in a horizontal direction, preferably in the direction in which loading/unloading of the substrate takes place.

Also, it may be possible that sensor transfer means and support transfer means are provided which can displace both the measurement sensor and the substrate relative to each other, in two horizontal and orthogonal directions.

In this way the outside dimensions of the measurement chamber need to be only slightly larger than the dimensions of the substrate to allow mapping of the wafer. When the substrate is circular, with a diameter of 300 mm or greater, the measurement chamber can fit within a horizontal square or rectangular cross section with the smallest dimension less than 100 mm larger than the substrate diameter. For the compactness of the system it is advantageous to have this smallest dimension at the side that is mounted against the substrate handling chamber.

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**Claims**

1. Assembly of a substrate measurement system comprising a first measurement chamber (30), and a substrate handling chamber (7) provided with substrate transfer means (10) and a substrate container interface (1) for receiving a substrate container  
5 (8), said substrate handling chamber (7) being provided with a first mechanical interface (50) to connect to the first measurement chamber, said first measurement chamber comprising a measurement instrument and being provided with a second mechanical interface (51) to connect to said substrate handling chamber (7), and said substrate transfer means (10) being arranged to transfer substrates between said  
10 substrate container (8) and said first measurement chamber (30) through said substrate handling chamber (7), characterised in that  
a second measurement chamber (39) is provided, which fits within the same dimensions as said first measurement chamber (30) and is provided with the same identical second mechanical interface (51) as said first measurement chamber (30) to  
15 replace said first measurement chamber (30).
2. Assembly of a substrate measurement system in accordance with claim 1, wherein said first mechanical interface (50) comprises a first coupling part (52) and a first mechanical support area (54) and said second mechanical interface (51) comprises a second coupling part (53) and a second mechanical support area (55); said second  
20 coupling part (53) being arranged to match said first coupling part (52) and said second mechanical support area (55) being arranged to match said first mechanical support area (54).
3. Assembly of a substrate measurement system in accordance with claim 1 or 2, wherein said second measurement chamber (39) is one of a set of measurement  
25 chambers (39, 40).
4. Assembly of a substrate measurement system in accordance with any of the preceding claims, wherein said substrate handling chamber (7) comprises two first mechanical interfaces (50) to connect two of said first measurement chambers (30, 31, 32, 33).

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5. Assembly of a substrate measurement system in accordance with any of the preceding claims, wherein said assembly comprises at least two substrate container interfaces (1, 2, 3).

6. Assembly of a substrate measurement system in accordance with any of the preceding claims, wherein said substrate container interfaces (1, 2, 3), said first mechanical interface (50) of substrate handling chamber (7) are identical so that each of said interfaces can connect at choice either to the interface of a substrate container (8, 9, 11) or to the second mechanical interface (51) of a measurement chamber (30, 31, 32, 33, 39, 40).

7. Assembly of a substrate measurement system in accordance with claim 6, wherein said substrate container interfaces (1, 2, 3) and said first mechanical interface (50) are FOUP interfaces.

8. Assembly of a substrate measurement system in accordance with claim 5, 6 or 7, wherein at least one of said substrate container interfaces receives said substrate container (8, 9, 11) from a substrate container storage system (19) by a transfer means.

9. Assembly of a substrate measurement system in accordance with any of the preceding claims, in which any of said measurement chambers, said substrate containers (8, 9) and said substrate handling chamber (7) is arranged to be gastight sealable.

10. Assembly of a substrate measurement system in accordance with any of the preceding claims, wherein said substrate container (8) comprises a closed housing with a removable door and, to connect to said substrate container interface (1), a mechanical interface which sealably engages with said housing, and said substrate container interface comprises a mechanism arranged to engage with and remove/relocate said removable door.

11. Assembly of a substrate measurement system in accordance with any of the preceding claims, wherein said first and second measurement chambers (30, 31, 32, 33, 39, 40) are capable of receiving a substrate, with said substrate being transferred in or out the measurement chamber by said substrate transfer means (10) and said measurement chambers being provided with substrate support means arranged to

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support said substrate, rotating means arranged to rotate said substrate support means, in order to facilitate substrate mapping measurements, and transfer means to displace a sensor of said measurement instrument relative to said substrate.

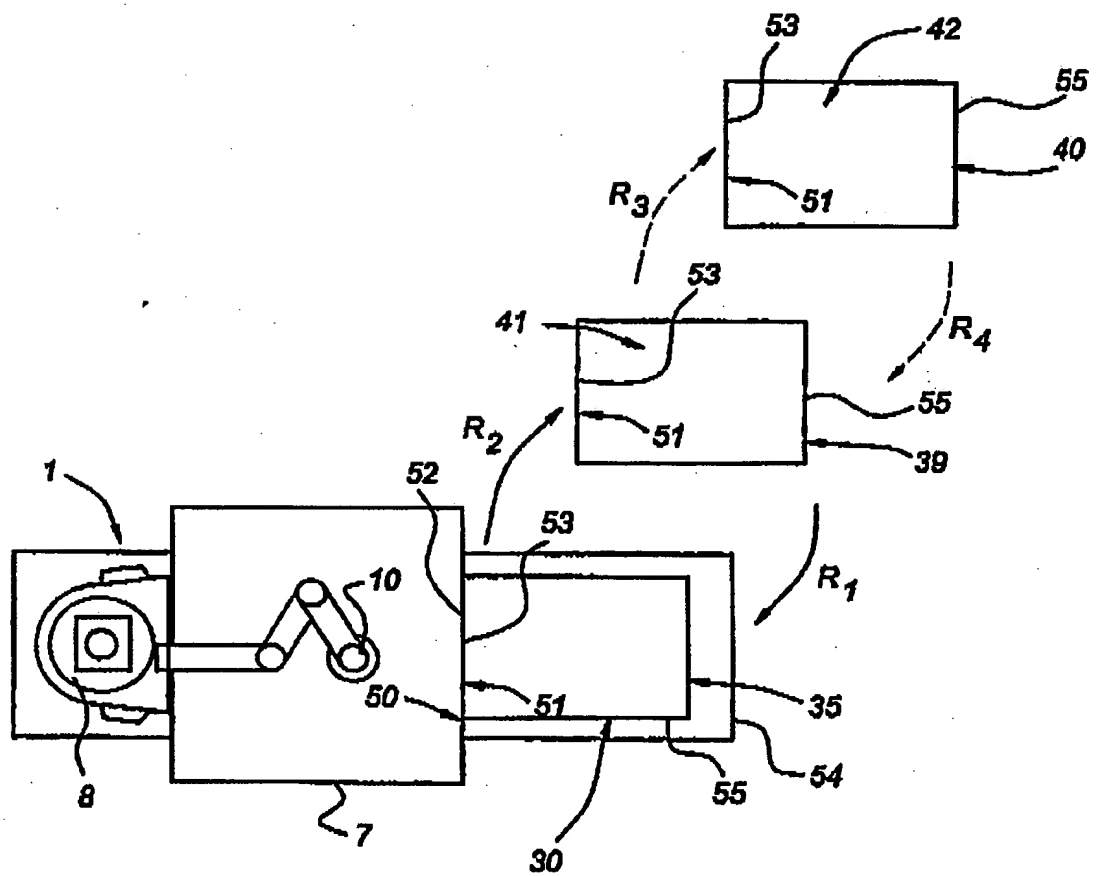
- 5 12. Assembly of a substrate measurement system in accordance with any of the preceding claims, wherein said first and second measurement chambers (30, 31, 32, 33, 39, 40) are capable of receiving a substrate, with said substrate being transferred in or out the measurement chamber by said substrate transfer means (10) and said measurement chambers being provided with substrate support means arranged to
- 10 support said substrate, rotating means arranged to rotate said substrate support means, in order to facilitate substrate mapping measurements, and transfer means to displace the substrate support means of the measurement instrument relative to the sensor of the measurement instrument.

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Fig 1

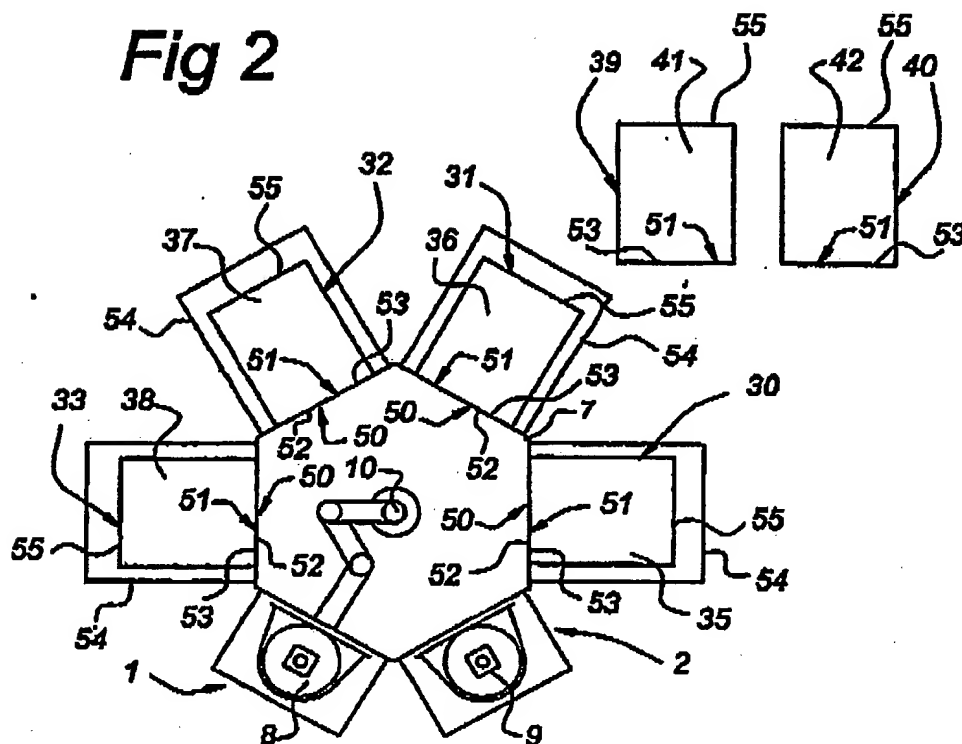
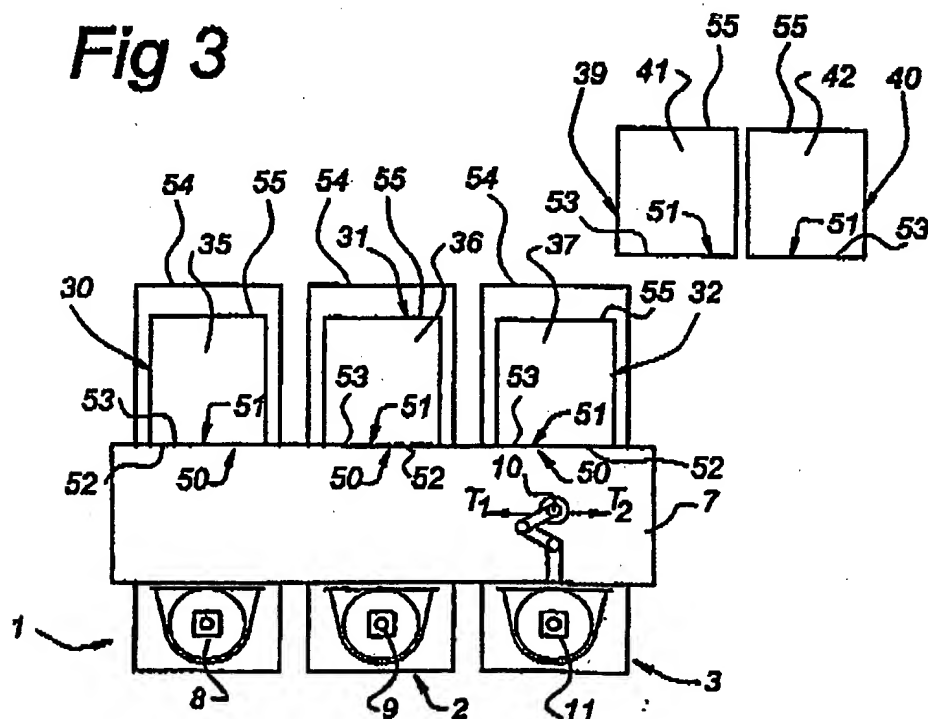




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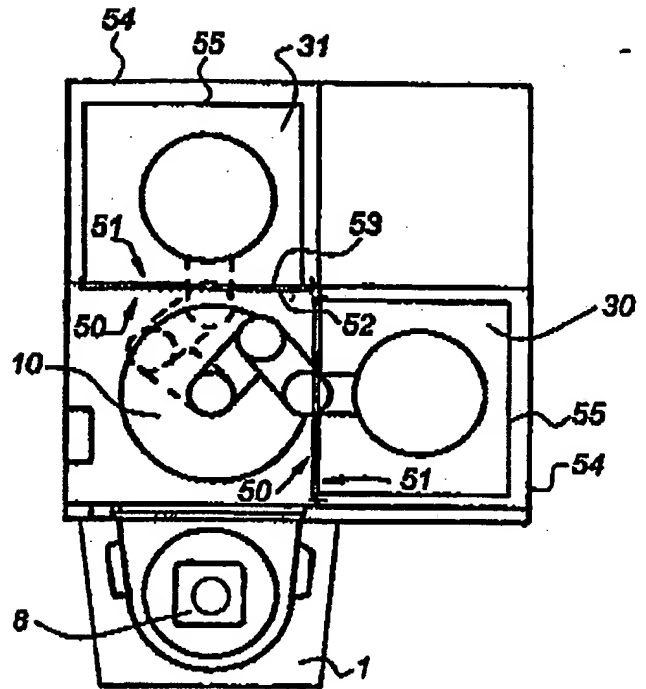
**Fig 2****Fig 3**

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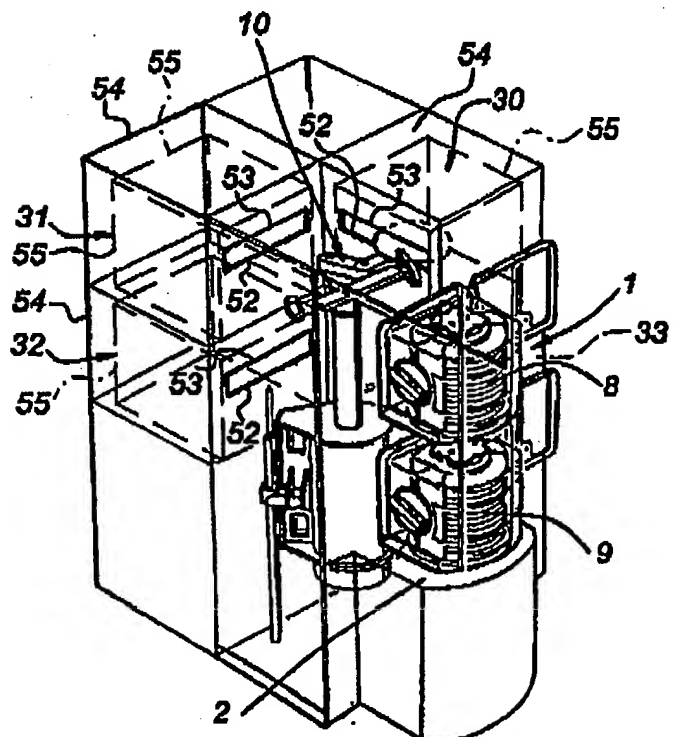
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**Fig 4a**



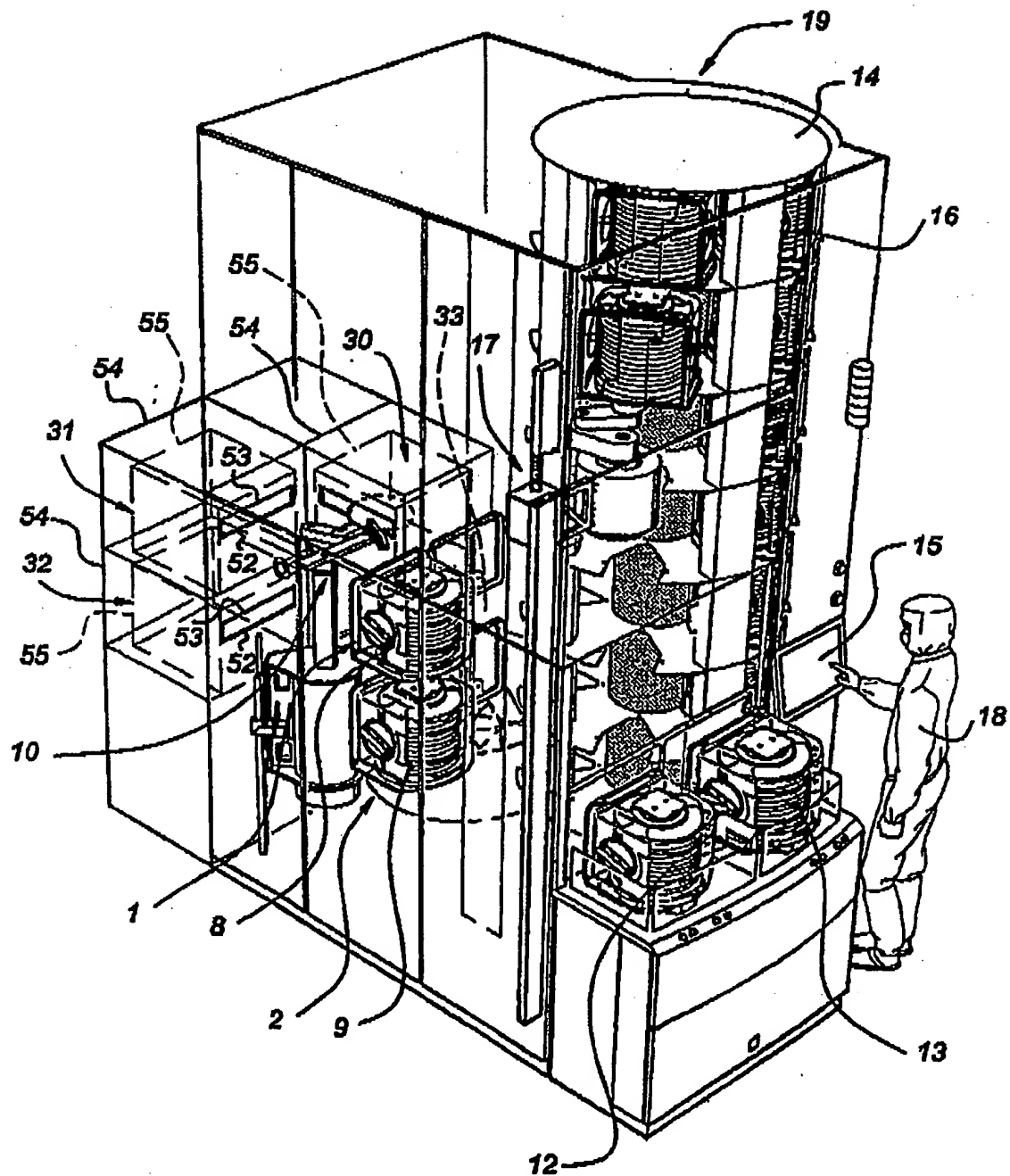
**Fig 4b**



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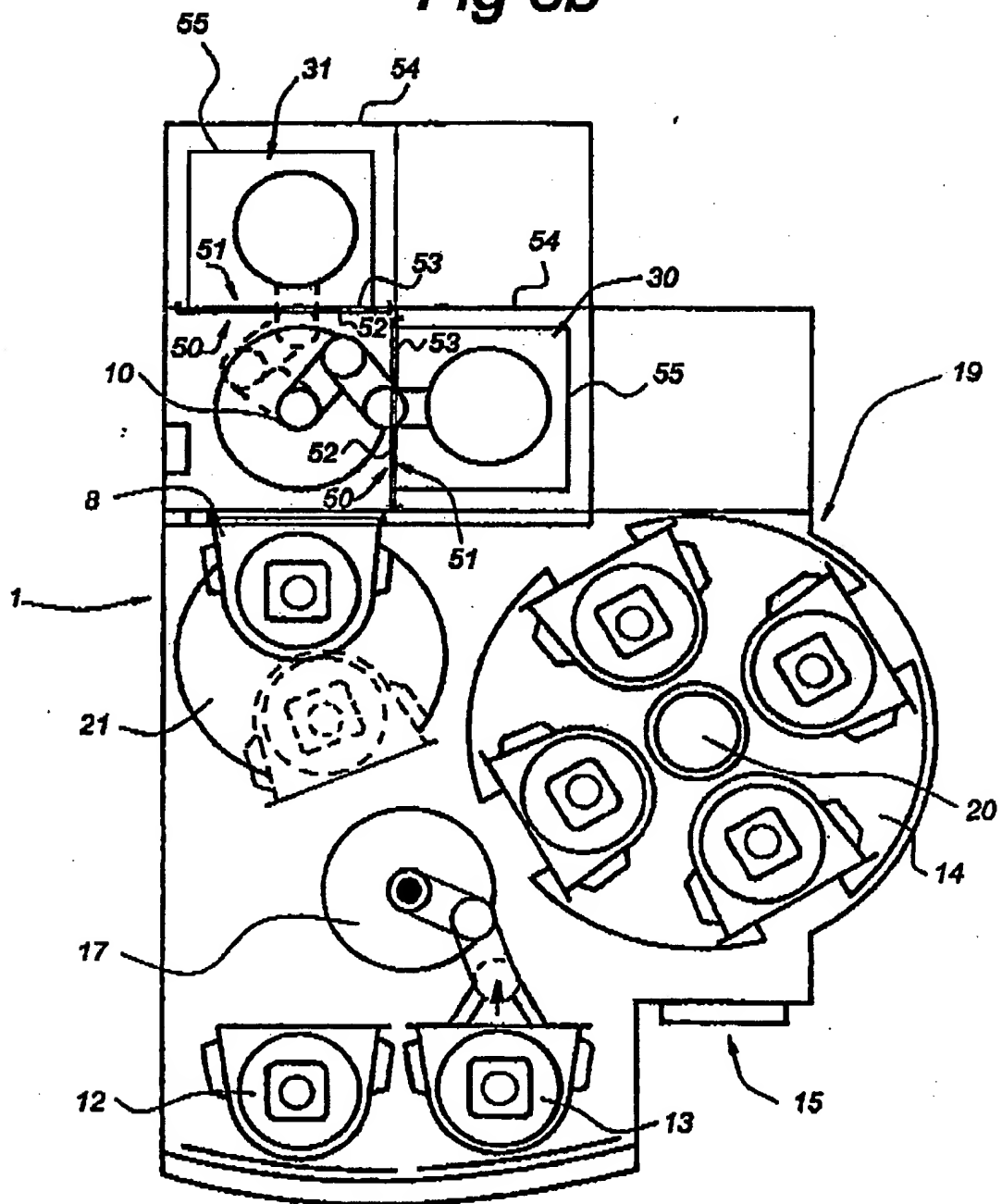
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*Fig 5a*

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**Fig 5b**

## INTERNATIONAL SEARCH REPORT

Internat. Appl. No.

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## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H01L21/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99 18603 A (APPLIED KOMATSU TECHNOLOGY) 15 April 1999 (1999-04-15) abstract page 5, line 17-25 page 22, line 4-7	1-5,8
Y		10-12
A		6
X	WO 99 03137 A (APPLIED MATERIALS) 21 January 1999 (1999-01-21) page 6, line 16-30	1,2,4,5
Y		10
A	US 6 013 920 A (GORDON ET AL.) 11 January 2000 (2000-01-11) abstract; figures 2-4	1



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Date of the actual completion of the international search

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**INTERNATIONAL SEARCH REPORT**Internal Application No  
**PCT/NL 01/00293**

<b>G.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
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**INTERNATIONAL SEARCH REPORT**

Information on patent family members

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